



Metabolic Syndrome Rather than Obesity Alone Is More Significant for Kidney Disease

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Abstract

Introduction Obesity is associated with metabolic syndrome, nonalcoholic steatohepatitis, and kidney disease. BMI may not be the ideal measure of obesity when used to assess its effect on kidney disease as it does not discriminate for age, sex, ethnicity, muscle, bone, or fat mass.

Objectives To assess the prevalence microalbuminuria and identify independent risk factors for development of kidney disease in the obese Indian population.

Methods Age, weight, BMI, total body fat percentage, waist-to-hip ratio, hypertension, urinary albumin-to-creatinine ratio (UACR), and HbA1c were collected from 568 obese patients, presenting for bariatric surgery. Multivariate binary logistic regression was used to identify independent risk factors for kidney disease.

Results A total of 114 out of 568 (20.07%) obese patients had microalbuminuria (UACR range 30–283 $\mu\text{g}/\text{mg}$). HbA1C levels ≥ 6 ($p = 0.01$) and hypertension ($p = 0.03$) were the strongest independent variables for microalbuminuria. 14.67% with a BMI $< 35 \text{ kg}/\text{m}^2$, 21.30% with a BMI 35–50 kg/m^2 , and 19.44% with a BMI $> 50 \text{ kg}/\text{m}^2$ had microalbuminuria. Increasing BMI however was not statistically significant ($p = 0.75$). Total body fat percentage ($p = 0.51$), waist-to-hip ratio ($p = 0.96$), age ($p = 0.30$), sex ($p = 0.38$), and BMI ($p = 0.75$) were found to be statistically insignificant.

Conclusions Kidney disease afflicts 1/5th of the obese Indian patients studied. Diabetes and hypertension remained as the most significant risk factors, while age, weight, increasing BMI, waist-to-hip ratio, or increasing body fat were found to be statistically insignificant for development and progression of kidney disease.

Keywords Microalbuminuria · UACR · Kidney disease · Obesity · BMI · Total body fat percentage · WHR · Age · Sex · Weight · Prevalence · Risk factors · Central obesity · T2DM · Hypertension · Metabolic syndrome

Introduction

Obesity is a worldwide health problem nearing epidemic proportions and is one of the most preventable causes of morbidity and mortality, with nearly one in six adults suffering from obesity and approximately 2.8 million individuals dying each year due to obesity or obesity-related complications [1]. Cardiovascular disease, type 2 diabetes mellitus (T2DM), dyslipidemia, systemic hypertension (HT), and chronic kidney disease have been described as obesity-related comorbidities with a steady increase in the development and progression of kidney disease [2]. The prevalence of obesity in the Western world has doubled in the last two decades with more than half of the adult population of the USA being overweight [3, 4].

Microalbuminuria, defined as a urinary albumin-to-creatinine ratio (UACR) of $\geq 30 \mu\text{g}/\text{mg}$, is used as an early indicator of kidney disease and diabetic nephropathy [5].

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Additionally, it has also been shown to be a predictor of cardiovascular events in adults [6]. Obesity has been implicated as an independent risk factor for the development of worsening microalbuminuria and chronic kidney disease, a faster decline in glomerular filtration rate, and its progression to end-stage kidney disease [7]. The proposed pathophysiological mechanisms for obesity-mediated kidney damage include hyperfiltration [8, 9], hyperactive renin-angiotensin-aldosterone system (RAAS), and sympathetic nervous system [10, 11], inflammatory mediators [12, 13], and hyperlipidemia [14]. At the same level of waist-to-hip ratio, South Asian populations seem to have an increased prevalence of metabolic syndrome and abdominal visceral fat and greater insulin resistance when compared with Caucasians [15, 16]. The South Asian population is at a higher risk of developing diabetic nephropathy and end-stage diabetic nephropathy at an early age as compared with Caucasian populations [17–19]. There is mounting evidence to suggest that body mass index (BMI) may not be the ideal measure of obesity, especially when used to assess its effect on kidney disease as it does not discriminate on basis of age, sex, ethnicity, muscle, bone, or fat mass [20]. Central obesity which is typically reflected by a high waist-to-hip ratio (WHR) has only recently been identified as a potential risk factor for renal disease in the nondiabetic population [21].

Few studies have studied the impact of the independent variability of T2DM and HT in an obese Indian population.

Objectives

The primary aim of the study was to assess the prevalence of kidney disease in the obese Indian population. The secondary objective was to identify independent risk factors for development of kidney disease in those studied.

Methods

In this observational study, data was collected from 573 obese individuals of Indian origin that presented to the Digestive Health Institute for preoperative assessment for bariatric surgery from January 2016 to December 2018. All patients considered for the study were obese with a BMI of ≥ 30 kg/m². The patients were assessed for age, sex, weight, BMI, total body fat percentage, waist-to-hip ratio, urinary albumin-to-creatinine ratio (UACR), and HbA1c. Blood pressure was measured twice in the sitting position. Patients' weight was measured to the nearest 0.2 kg with a weighing scale; height was measured to the nearest 0.5 cm. Serum creatinine levels and blood urea nitrogen (BUN) of all patients were estimated. The patients were then stratified into subgroups of those with T2DM alone (defined as people with a known history of T2DM or newly identified disease on anti-diabetic medication or with a HbA1c ≥ 6), those with HT

alone (defined as people with a known history of HT or newly identified disease or already on anti-hypertensive medication), those with both T2DM and HT, and those patients with neither T2DM nor HT. Five patients were excluded from this study as they had undergone a bariatric procedure earlier and had presented for a revision surgery, so as to avoid any confounding characteristics. All laboratory investigations were performed at the same laboratory at Saifee Hospital, Mumbai, India. Microalbuminuria was defined as having a urinary albumin-to-creatinine ratio (UACR) of ≥ 30 μ g/mg.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Statistical Analysis

Multivariate logistic regression analysis was performed to compare the level of microalbuminuria with age, weight, BMI, total body fat percentage, waist-to-hip ratio, HbA1c, and HT to determine which variable held statistical significance. Additionally, the relation of microalbuminuria with tertiles of weight, BMI, total body fat percentage, WHR, and HbA1c was studied in different groups in those with T2DM alone, HT alone, both T2DM and HT, and with neither T2DM nor HT ($n = 568$). Continuous variables were expressed as means \pm SD. Unpaired Student's *t* test was used for continuous variables and chi-square test was used to evaluate differences in proportions.

Results

The study population was primarily of Indian origin. Of the 568 subjects, 56.69% were women and 43.3% were men. The mean age group was 44.25 years \pm 11.8, with a mean BMI of 43.51 kg/m² \pm 7.80, a mean total body fat percentage of 49.58% \pm 9.90, and a mean WHR of 1.06. The subgroup division based on comorbidities was 21.12% (120/568) patients with T2DM alone, 13.02% (74/568) with HT, 31.33% (178/568) with both T2DM and HT, and 34.50% (196/568) with neither T2DM nor HT (Table 1).

Demographic and clinical characteristics of this cohort are presented in Table 2.

20.07% (114/568) of patients had microalbuminuria (UACR range 30–283 μ g/mg). 24.79% (61/246) men had microalbuminuria as compared with 16.45% (53/322) women. Of those with T2DM alone, 25.83% (31/120) had microalbuminuria. Of those with HT alone, 17.56% (13/74) had microalbuminuria. Of those with both T2DM and HT,

Table 1 Total distribution of demographics

	T2DM	HT	T2DM+HT	Neither	Total
Total	120 (21.12%)	74 (13.02%)	178 (31.33%)	196 (34.50%)	568
Men	58	24	97	67	246
Women	62	50	81	129	322
Age < 30	14	3	3	53	73
Age 30–50	63	49	79	121	312
Age > 50	43	22	96	22	183
BMI < 35	11	2	22	40	75
BMI 35–50	84	53	122	126	385
BMI > 50	25	19	34	30	108
HbA1c < 6	7	51	16	180	254
HbA1c ≥ 6	113	23	162	16	314

32.02% (57/178) had microalbuminuria. In those who had neither T2DM nor HT, 6.63% (13/196) had microalbuminuria.

Age-based subdivisions showed that in those with T2DM alone (120/568), 7.14% (1/14) < 30 years of age had microalbuminuria, 25.40% (16/63) between 30 and 50 years of age had microalbuminuria, and 32.56% (14/43) > 50 years of age had microalbuminuria.

In those with HT alone (74/568), none (0/3) of the patients < 30 years of age had microalbuminuria, 20.41% (10/49) between 30 and 50 years of age had microalbuminuria, and 13.64% (3/22) > 50 years of age had microalbuminuria.

In those with both T2DM and HT (178/568), 33.33% (1/3) < 30 years of age had microalbuminuria, 29.11% (23/79) between 30 and 50 years of age had microalbuminuria, and 34.38% (33/96) > 50 years of age had microalbuminuria.

In those with neither T2DM nor HT (196/568), 7.55% (4/53) < 30 years of age had microalbuminuria, 4.96% (6/121) between 30 and 50 years of age had microalbuminuria, and 13.64% (3/22) > 50 years of age had microalbuminuria.

BMI-based subdivision showed that for those with T2DM alone (120/568), 27.27% (3/11) with BMI < 35 kg/m² had microalbuminuria, 27.38% (23/84) with BMI between 35 and 50 kg/m² had microalbuminuria, and 20% (5/25) with BMI > 50 kg/m² had microalbuminuria. In those with HT alone (74/568), none (0/2) with BMI below 35 kg/m² had microalbuminuria, 16.98% (9/53) with BMI between 35 and 50 kg/m² had microalbuminuria, and 21.05% (4/19) with BMI > 50 kg/m² had microalbuminuria. In those with both T2DM and HT (178/568), 31.82% (7/22) with BMI < 35 kg/m² had microalbuminuria, 33.61% (41/122) with BMI between 35 and 50 kg/m² had microalbuminuria, and 26.47% (9/34) with BMI above > 50 kg/m² had microalbuminuria. In those with neither T2DM nor HT (196/568), 2.5% (1/40) with BMI < 35 kg/m² had microalbuminuria, 7.14% (9/126) with BMI between 30 and 50 kg/m² had microalbuminuria, and 10% (3/30) with BMI > 50 kg/m² BMI had microalbuminuria.

Based on these findings, age, sex, weight, BMI, total body fat percentage, WHR, HbA1c, and HT were used as potential correlates of microalbuminuria in a multivariate binary logistic regression model (Table 3). HbA1C levels ≥ 6 ($p = 0.01$) and HT ($p = 0.03$) emerged as the strongest correlates of microalbuminuria. There was no statistically significant correlation for age ($p = 0.30$), sex ($p = 0.38$), weight ($p = 0.09$), BMI ($p = 0.75$), total body fat percentage ($p = 0.50$), or WHR ($p = 0.95$) as independent variables.

Discussion

For some time now, the belief that obesity is responsible for the development and progression of kidney disease has gained ground and a lot of studies have shown results to back such a theory. In our study, 20.07% of those patients with obesity had microalbuminuria, which made it 1/5th of the population studied. This is consistent with the findings of Chen et al.'s study on the Chinese population which showed microalbuminuria in 19.5% of their total population [22]. Tapp et al. similarly reported in their study that microalbuminuria was found in 21.0% among European origin individuals [23]. Thus, it could be implied here that obesity alone is not an independent risk factor for the development of kidney disease. Metabolic syndrome has been proven to be an independent risk factor in the development and progression of kidney disease. Since the Indian population is known to develop metabolic syndrome at much lower BMIs than the Caucasian population, metabolic syndrome especially T2DM and HT and not increasing BMI would be better predictors of kidney damage, thus necessitating advanced screening and surveillance for at-risk populations. This probably proves that obesity alone in the absence of metabolic syndrome does not impact chronic kidney disease.

Table 2 Demographic distribution and prevalence between patients with normal UACR and those with microalbuminuria

	Normal UACR				Microalbuminuria			
	T2DM	HT	T2DM+HT	Neither	T2DM	HT	T2DM+HT	Neither
Total	89/120 (74.17%)	61/74 (82.43%)	121/178 (67.98%)	183/196 (93.38%)	31/120 (25.83%)	13/74 (17.57%)	57/178 (32.02%)	13/196 (6.63%)
Men	38/58 (65.52%)	18/24 (75.00%)	69/97 (71.13%)	60/67 (89.55%)	20/58 (34.48%)	06/24 (25.00%)	28/97 (28.87%)	07/67 (10.45%)
Women	51/62 (82.26%)	43/50 (86.00%)	52/81 (64.20%)	123/129 (95.35%)	11/62 (17.74%)	07/50 (14.00%)	29/81 (35.80%)	06/129 (4.65%)
Age < 30	13/14 (92.86%)	03/03 (100%)	02/03 (66.67%)	49/53 (92.45%)	01/14 (7.14%)	0	01/03 (33.33%)	04/53 (7.55%)
Age 30–50	47/63 (74.60%)	39/49 (79.59%)	56/79 (70.89%)	115/121 (95.05%)	16/63 (25.40%)	10/49 (20.41%)	23/79 (29.11%)	06/121 (4.96%)
Age > 50	29/43 (67.44%)	19/22 (86.36%)	63/96 (65.63%)	19/22 (86.36%)	14/43 (32.56%)	03/22 (13.64%)	33/96 (34.38%)	03/22 (13.64%)
BMI < 35	08/11 (72.73%)	02/02 (100%)	15/22 (68.18%)	39/40 (97.50%)	03/11 (27.27%)	0	07/22 (31.81%)	01/40 (2.50%)
BMI 35–50	61/84 (71.62%)	44/53 (83.02%)	81/122 (66.39%)	117/126 (92.86%)	23/84 (27.38%)	09/53 (16.98%)	41/122 (33.60%)	09/126 (7.14%)
BMI > 50	20/25 (80.00%)	15/19 (78.95%)	25/34 (73.53%)	27/30 (90.00%)	05/25 (20.00%)	04/19 (21.05%)	09/34 (26.47%)	03/30 (10.00%)
HbA1c < 6	06/07 (85.71%)	41/51 (80.39%)	15/16 (93.75%)	168/180 (93.33%)	01/07 (14.29%)	10/51 (19.60%)	01/16 (6.25%)	12/180 (6.67%)
HbA1c ≥ 6	83/113 (73.45%)	20/23 (86.96%)	106/162 (65.43%)	15/16 (93.75%)	30/113 (26.55%)	03/23 (13.04%)	56/162 (34.57%)	01/16 (6.25%)

In our study, microalbuminuria was found in 24.79% (61/246) of men and 16.45% (53/322) of women. Chen et al. reported microalbuminuria in 16.4% of men and 21.7% of women in their study [22]. Afkhami-Ardekani et al. reported microalbuminuria in 14.9% of men and 13.6% of women in their study [24].

Out of 568 patients studied, we found that 21.13% (120/568) had T2DM alone, 13.03% (74/568) had HT alone, 31.34% (178/568) had both T2DM and HT, and 34.50% (196/568) had neither. The prevalence rates of microalbuminuria in those patients with only T2DM were found to be 25.83% (31/120); in those with HT alone, it was 17.57% (13/74); and in those with both T2DM and HT, it was 32.02% (57/178). In those who had neither T2DM nor HT, microalbuminuria was seen in 6.63% (13/198) only. T2DM ($p = 0.01$) and HT ($p = 0.03$) proved to be the most significant independent factors responsible for increase of microalbuminuria in our study. Tapp et al. found in their study that the prevalence of microalbuminuria increased with increasing HbA1c levels significantly ($p = 0.001$), with the prevalence of between 24.1 and 35.9 in patients with an HbA1c level > 6. Hypertension was also identified as a significant risk factor ($p < 0.001$) [23]. Xiao-Hong Li et al. found in their study that T2DM ($p < 0.0001$) and HT ($p = 0.014$) strongly correlate with microalbuminuria. In the study published by Liese et al. on microalbuminuria, central adiposity, and hypertension in the nondiabetic urban population of Augsburg, they found HT ($p = 0.0001$) to be strongly associated with microalbuminuria [25].

When patients in our study with microalbuminuria were divided across age groups, we found that 8.22% (1/14) < 30 years of age, 17.63% (16/63) between 30 and 50 years of age, and 28.96% (14/43) above 50 years of age had microalbuminuria. There was an increase in the prevalence of microalbuminuria seen with advancing age; however, it was not found to be statistically significant ($p = 0.30$). Afkhami-Ardekani et al. similarly found microalbuminuria in 8% > 30 years of age, in 21% between 30 and 50 years of age, and 12% > 50 years of age. They reported no significant statistical correlation between age and microalbuminuria [24]. Chen et al. however despite noting a similar prevalence of microalbuminuria of 15.3% in those < 30 years of age, 18.8% between 30 and 50 years of age, and 26.6% > 50 years of age reported statistical significance in correlation to microalbuminuria in their study unlike ours [22].

When patients with microalbuminuria were divided across BMI groups in our study, we reported a prevalence of microalbuminuria of 14.67% in patients with BMI < 35 kg/m², 21.30% in those with BMI 35–50 kg/m², and 19.44% in those with BMI > 50 kg/m². Though there was an increase in the prevalence rates with increasing BMI, it was not found to be statistically significant ($p = 0.75$). This was corroborated in the report of Afkhami-Ardekani et al. who showed that the

Table 3 Multivariate logistical regression analysis

	<i>p</i> value	Lower 95%	Upper 95%
Total body fat %	0.507146432364976	−4.239028721995	8.565829826301
Waist-to-hip ratio	0.954573241247154	−15.6016262784056	14.7218131983689
Weight	0.095919645876156	−4.59882503010956	0.375348877509878
BMI	0.751410322974276	−6.77167399958196	9.37740956547242
Hba1c	0.0126072646950246	5.05694120434087	41.9451896051254
HT	0.0315853838838272	6.10760659329837	131.846376379933
Age	0.304139643886096	−1.32052019940871	4.22368968309728
Sex	0.38083606894682	−163.86413468206	62.7000520602725

prevalence of microalbuminuria among patients with BMI < 25 kg/m² was 17.9% and in those with BMI of > 25 kg/m², prevalence was 12.9%. There was no statistical significance found between microalbuminuria and body mass index ($p = 0.272$) in their study as well [24]. Atta et al.'s study in obese and non-obese populations found the prevalence of microalbuminuria to be 15.9% in the obese population with an average BMI of 37.5 kg/m² as compared with 10.2% in the non-obese population with a BMI of 24.2 kg/m². They reported that UACR significantly increased in the obese group as compared with that of the non-obese group ($p = 0.008$) [26]. Ferris et al. reported a nonlinear association between BMI and microalbuminuria only in those with a BMI > 35 kg/m², which was found to be statistically significant ($p = 0.04$) in their study [27]. Kenealy et al. in their study comparing microalbuminuria in Maori, European, and Indo Asian diabetic populations of New Zealand found that a rising BMI is associated with microalbuminuria in all non-European groups such as the East Asian, Indian, Pacific, and Maori, which would support priority access to bariatric surgery for these groups [28].

In our study, we found that total body fat percentage ($p = 0.51$) and WHR ($p = 0.96$) were statistically insignificant for microalbuminuria. Liese et al. in their study found overall obesity ($p = 0.33$) and elevated waist circumference ($p = 0.3$) were not predictive of microalbuminuria which matches the findings of our study [25].

Since the Indian population is known to develop metabolic syndrome at much lower BMIs than the Caucasian population, metabolic syndrome especially T2DM and HT and not increasing BMI would be better predictors of kidney damage. Thus, it is imperative that patients with T2DM, HT, and T2DM+HT need enhanced screening and surveillance to prevent development and progression of kidney disease.

Conclusions

Kidney disease afflicts 1/5th of the obese Indian patients studied. T2DM and HT remained as the most significant risk

factors for kidney disease while age, weight, increasing BMI, WHR, and increasing total body fat percentage were found to be statistically insignificant for the development and progression of kidney disease. Thus, it is imperative that patients with metabolic syndrome need enhanced screening and surveillance to prevent development and progression of kidney disease.

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Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Conflict of Interest The authors declare that they have no conflicts of interest.

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